to the consternation of the framers of this foolish prohibition, the premium on gold soared higher than ever. The result was a hasty and shamefaced repeal.

Experience of this kind is too common in economic legislation. It serves as a warning that we should know something of economic science before venturing to tamper with economic conditions. The men who need this warning most of all are those who despise all 'theories' and call themselves 'practical.' It is they who legislate a measure one day and have to repeal it the next. A *truly* practical man can predict how a measure will work, and his power so to do requires not only what is called 'practical' but also what is called 'theoretical' knowledge; a knowledge, in short, not only of *history* but of *science.*

IRVING FISHER.

YALE UNIVERSITY.

SECTION D—MECHANICAL SCIENCE AND ENGINEERING.

THE meetings of the section were held in the lecture room of Sibley College of Mechanical Engineering and Mechanic Arts, of Cornell University, on Friday and Saturday, June 29 and 30. They were followed by the fourteenth annual meeting of the Society for the Promotion of Engineering Education, an affiliated society of the association.

In the absence of the vice-president, the retiring vice-president, Fred W. McNair, president of the Michigan College of Mines, acted as chairman of the section. Twenty-three members of the association registered as belonging to the section, while members of other sections attended some of the meetings. Experience gained at this meeting has shown that it is not conducive to the greatest attendance to have Sunday intervene between the meetings of the section and of the affiliated society.

The first two papers were by Byron B.

Brackett, professor of physics and electrical engineering of the Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y. The first paper describes a 'Lamp Bank composed of Small Separate Units.' Each unit consists of twelve incandescent lamps arranged in a partially open box, 28 inches long and 10 inches square. The boxes are open enough to give perfect ventilation. On one side are placed switches for cutting in or out the lamps of that particular box, and for changing the grouping of the lamps into parallel, series or combination arrangements. As many of these units as are desired may be placed one upon the other in tiers, and as many tiers as are needed may be placed side by side to form a lamp bank of any capacity. Each unit is constructed to permit convenient interconnection with the adjacent ones. Thus, the large bank may be separated into smaller ones whenever desired and reassembled with the least possible loss of time and effort for special tests on large machines.

His second paper was on an 'Alternating Current Wave-form Apparatus.'

To set the armature accurately for the separate readings in the ballistic method of tracing the E.M.F. wave of an alternator, a double or duplicate brake apparatus is unusually satisfactory. Two similar clamp brakes with long arms are placed on the pulley side by side. With the arms held rigidly the desired readings for one observation are made. Then brake No. 1 is unclamped at the pulley, the end of its arm released and rotated up a short distance to a fixed stop. Brake No. 1 is now clamped to the pulley, brake No. 2 is unclamped, the end of No. 1 turned down to its original position and No. 2 is clamped again. Thus the armature has been rotated through a small angle, that may be computed with great accuracy from the length of the arms and the distance

through which the end of the arm of No. 1 is moved. The same method may be used wherever small accurate rotations of any shaft are desired and the same apparatus may be used on dynamos, engines and other forms of machinery.

A report was made by Mansfield Merriman, professor of civil engineering, Lehigh University, South Bethlehem, Pa., on 'Constant and Probable Errors in the Estimation of Linear Distances and Vertical Angles, as ascertained by 1,712 Observations on 128 Students.'

The observations were made by asking students to record their estimates of the length, width and thickness of a board, and also of the magnitude of several vertical angles. The angles were estimated in degrees and also by the ratio of horizontal to vertical projection. The following conclusions were drawn:

1. For lengths, about sixty per cent. of the estimates were too large, and the average constant error was always positive.

2. For angles, about eighty per cent. of the degree estimates, and about sixty per cent. of the ratio estimates, were too large.

3. The estimates of vertical angles by the ratio method are more accurate than those by degrees.

4. The probable error of a single estimate is larger than the average constant error.

5. The estimates of the freshmen class had much larger errors than those of other classes.

This interesting example of the application of laboratory methods to the class-room created much interest on the part of the engineering teachers present.

The next paper was read by the secretary, and described and discussed the results of 'Some Experiments on the Frictionless Orifice' and was by Horace Judd and Roy S. King, assistant professors of experimental engineering at Ohio State University. The paper is in sequence with one presented by one[1] of the authors at the St. Louis meeting, on 'Pitot Tubes; with Experimental Determinations of the Form and Velocity of the Jets,' and which was published in the *Engineering News* of March 31, 1904, page 318.

The experiments described in the paper were made on five frictionless orifices, ranging in size from three fourths inch to two and one half inches in diameter. The term 'frictionless orifice' is one which has been commonly used in the mechanical laboratory at the Ohio State University for many years. It is the same as what some of the text-books call 'an orifice in a thin plate,' and indicates that there is no appreciable loss by friction by a stream of water flowing through such an orifice. So far as known, the term was first employed as early as 1873 by Professor S. W. Robinson, emeritus professor of mechanical engineering at the Ohio State University, and will be found on page 552 of Vol. VI. of the Geological Reports of Ohio, 1886, in his report on the 'Measurement of Gas Wells and other Gas Streams and the Piping of Natural Gas.'

The facilities available consisted of a closed standpipe into which several pumps could force water. A horizontal drum was connected near the bottom of the standpipe, and in the end of the drum the orifice to be tested was secured; the coordinates of the issuing jets were measured by the hydraulic micrometer caliper, described in a paper presented by Professor Wm. T. Magruder at the St. Louis meeting of the association.[2] The water was caught and measured in a calibrated cistern.

The experiments were made to find:

[1] Science, N. S., Vol. XIX., No. 479, March 4, 1904, p. 364.

[2] Science, Vol. XIX., No. 479, March 4, 1904, p. 364.

1. The coefficient of discharge by direct measurement in a calibrated hydraulic cistern, (a) to verify existing constants, and (b) to find the coefficient of velocity for comparison with that given by the Pitot tube, and (c) to verify its constant. The results show a decrease in the coefficient of discharge of 2.5 per cent. with an increase in the diameter of the orifice from three fourths inch to two and one half inches. The average value obtained was 0.60664, and is about 1.8 per cent. greater than that given in Merriman's 'Hydraulics' (0.5960). Compared with that of Bovey (0.6000), the result obtained with the jet from the one inch orifice (0.6097) is 1.6 per cent. higher.

2. The shape of the jet in the vicinity of the least section as found by exploring the contour of the jet by the special micrometer caliper. It was found that the distance from the face of the orifice to the least section of the jet varied from 1.6 radii for the three fourths inch orifice to about one radius for that two and one half inches in diameter. Text-books on hydraulics give this distance as being one radius, while Bazin found no 'minimum section' of the jet flowing through a large orifice and under low head.

3. The diameter at least section, as found by the special caliper for four different positions, 45° apart. From the average diameters, the coefficients of contraction were 'computed, and they were found to decrease from 0.6134 for the three fourths inch orifice to 0.5955 for the two and one half inch orifice, with an average value of 0.60674. As calculated from the average results for the coefficients of discharge, the coefficient of velocity is the quotient of the coefficients of discharge and contraction, or 0.60664 divided by 0.60674 equals 0.99983. From this result it is thought that the term 'frictionless orifice' is justifiable.

4. The effect of increase of static pres-

sure on least section. No appreciable increase was found in the diameter of the least section of the jet from a one inch orifice by increasing the pressure from 5 pounds to 100 pounds; and, for pressures as high as 40 pounds, only a slight increase was noticed for the orifices one and one half inches to two and one half inches in diameter. This latter was probably due in part to the increased roughness of the contour of the larger streams.

5. The velocity in the least section was found by traversing the jet with a one fourths inch Pitot tube used in connection with a differential manometer. It is thought that the coefficient of velocity as determined by the Pitot tube is unity within a negligible fraction of 1 per cent. and that the velocity is uniform throughout the section. As calculated from the average values of the coefficients of discharge and contraction as determined by experiment, the coefficient of velocity was found to be 0.99983. This compares very well with the average value of the coefficient of velocity, 0.99993, determined by means of the Pitot tube. This would seem to verify the statement that the Pitot constant is unity.

The paper shows that it is the result of most careful and elaborate investigations. It also shows the inaccuracy of certain statements which are still being published in books on hydraulics concerning the vena contracta. While adding new facts to our knowledge, it gives us a method for measuring quantities of water discharged, and with a probable error which is known to be small and less than the probable error of observation. The paper is worthy of careful study and attention. It will probably be published in the *Engineering News.*

The next paper on the program was on 'Some Aspects of the Panama Canal,' by Wm. H. Burr, professor of civil engineering, Columbia University, New York, N.

Y., and a former member of the Isthmian Canal Commission. As the paper has been published in full, and will be found on page 71 of the issue of SCIENCE for July 20, 1906, its contents need not be detailed here. Suffice it to say that the recent dreadful earthquake disaster at San Francisco constitutes the gravest warning in human experience of the advisability of constructing this canal in such a way as to give it the greatest degree of immunity from the results of any convulsions of nature, and the still more recent earthquake shocks on the isthmus should be sufficient to set even politicians to thinking what would be at least one result of an earthquake to the gates and walls of a lock canal having 85 feet of lift.

In this connection it should be noted that while no efforts have been made to secure authors of papers who were in favor of the sea-level canal, yet all the papers which have been presented before this section in the last few years have logically given most excellent reasons why the canal should be built with the fewest possible locks and of the least lift. Time will decide whether the prediction is correct which has been made before this section that the high lock level canal will have to be rebuilt before it has been in use ten years.

Henry T. Eddy, professor of engineering and mechanics, University of Minnesota, Minneapolis, Minn., presented a paper on 'The Theory of the Flexure of the Symmetrically Loaded Plate, and the Heavy Horizontal Disc of Varying Thickness.' Although the theory of the elastic flexure of the thin flat plate of uniform thickness has been long known to the same degree of approximation as that of the common theory of flexure of beams, the theory of the heavy horizontal disc on a vertical axis and of a thickness decreasing from the axis of the rim has, up to the present time, been

in a somewhat unsatisfactory state from the point of view of the engineer who would design discs like those employed in the Curtis steam turbine. The object of this paper is to make a contribution to this theory, which it is hoped will facilitate both the algebraic and numerical treatment of such units of construction.

A paper was read and illustrated by Henry S. Jacoby, professor of bridge engineering, Cornell University, Ithaca, N. Y., on the 'Applicability of Displacement Diagrams in the Design of the Flanges of Arch Ribs with Solid Webs.'

The usual method of finding the stresses in the flanges of arch ribs with solid web plates involves the computation of bending moments and axial thrusts at a number of sections due to dead and live loads, and also when there are less than three hinges, for changes of temperature and rib shortening. The formulas for the determination of the horizontal reactions, while comparatively simple for ribs with a parabolic axis, are complex for a circular axis, and entirely impracticable for other curves such as three or five centered ovals. The method proposed is to assume the solid web plate to be temporarily replaced by an imaginary inelastic system of open webbing, the panel points of each chord being located in the centers of gravity of the corresponding flange sections. It allows the horizontal reactions to be found by means of displacement diagrams which apply to any form of arch rib. The method also affords the simplest means of finding the deflections under any loading.

'Some Notes on the Teaching of the Cyclic Analysis of the Gas Engine' was next presented by Arthur J. Wood, assistant professor of experimental engineering, Pennsylvania State College, State College, Pa.

As a basis for this study and discussion, the results of tests of a five-horse-power

gasoline engine were presented in full. The distribution of heat thus obtained is compared with results obtained by an entropy-temperature analysis of one of the indicator diagrams in which the losses are shown graphically. The paper brings out the method for finding the temperature at any point in the card; the heat of the mixture in the cylinder; the average value for the exponent of the adiabatic curves of expansion and of compression and values for different parts of these curves; the method of obtaining the entropy for all points; and a comparison of results of some recent tests at the Pennsylvania State College.

Certain conclusions are drawn from the study of the subject: (1) the losses can not be computed accurately unless the data are taken more completely and with greater care than is usual with such tests; (2) about 20 per cent. of the heat of the gasoline vapor is available for useful work at full load; (3) the common method of obtaining, by test, the heat in the exhaust gases is not satisfactory; (4) the teaching of the entropy-temperature analysis without requiring the student to make the analysis is a pure waste of time (the average student in the senior class ought to master the whole theory in a few hours, and make the analysis in a few days' time, and this will open to him some of the neatest applications of thermodynamics; a complete analysis by a student is presented in the paper); (5) the value of the exponent of the true adiabatic curve is obtained from the ratio of the specific heat at constant pressure to the specific heat at constant volume, and if this curve is constructed it will bring out at a glance where heat is taken in or given out, without resorting to the entropy-temperature diagram. Brief reference is made to the method known as 'cyclic analysis,' in which the principal results as mean effective pressure are obtained from the heat put in, the initial temperature, the value of the specific heat at constant volume and the temperature after compression. The author has found this method to contain nothing attractive as a system for teaching, because, (1) it makes the student a mere machine, substituting in derived formulas; (2) the value of the heat for each cycle can not be obtained accurately by this method; and (3) it does not open up clear, well-defined lines of application of the principles of thermodynamics. The paper as a whole aims to make it clear what data must be obtained in order to make an entropy temperature analysis and how it may be made practical as a method of instruction and valuable in design. It further shows how the principles of thermodynamics can be made as clear in showing changes of heat energy as of mechanical energy. In all this the writer does not depreciate the value of the purely analytical methods.

The next paper was by W. W. Churchill, vice-president and chief engineer of the Westinghouse, Church, Kerr Company of New York, on 'The Preservation of Surface Condenser Tubes in Plants using Salt or Contaminated Water Circulation.' The paper will be published in full in the October issue of *Power*.

Owing to electrolytic and galvanic action on the tubes of a surface condenser using water containing salt or sewage for circulation, the use of surface condensers in large power plants has been very largely abandoned as useless. Under ordinary circumstances the water bill of such a plant as that described for the Long Island City power house of the Pennsylvania Railroad, containing when fully constructed fourteen 5,500 K.W. generating sets, would be in the neighborhood of $100,000. An investigation was undertaken of possible methods for preventing the rapid destruction of the condenser tubes and parts of the condenser.

The most competent opinion that could be obtained was that if the differences of potential due to stray ground traction or other currents could be adjusted to be within three volts or less, the difficulty would cease, as the trouble was all due to stray grounded currents from electric railways. To that end, the stray currents were measured, and at times a difference of potential of nine volts higher than the harbor was discovered between the railroad rails in the freight yard and the river, producing a considerable flow of current from all parts of the water piping and other metallic substances in the vicinity of the power house site to the harbor.

In order to properly study the real conditions, a number of glass jars were provided and various combinations of metals were immersed in samples of water taken from the river, of sea water, and of pure water. The action of the river water was much more violent than ordinary sea water. It was further observed that there was a local action going on which was galvanic, and that the amount of stray currents caused the galvanic action to be exceedingly violent, and that thin copper tubes were destroyed at a very rapid rate. They would be punctured in from four to five days, which would make their use fatal in commercial practise. It is thus evident that there was a violent action between the zinc and copper of the brass tubes which were in contact with the electrolyte. Even when unconnected, or electrically separated, plates of brass were placed in this electrolyte, any projections were promptly destroyed. But if an electric battery having a pressure exceeding that of the couple in the East River water was caused to act to produce a counter current, and having a pressure exceeding that of the galvanic couple, the capacity of this electrolyte to drive off atoms of the mechanically combined metals of the alloys used was over-

come and corrosion was arrested. To do this it was planned in this case, where this couple is about 0.4 of a volt, to put a counter pressure of 0.6 of a volt on the anode. In order to insulate the condenser as much as possible from stray currents from the railway, the joints in the piping and the ground contacts were insulated, and even the large water connections were lined with glass melted on to the surface. To furnish the desired electromotive force a three-K.W. motor-generator was installed and provided with switchboard apparatus and appliances, together with ammeters and voltmeters, and a connection to the outlying anode in the condensing supply intake at its harbor end. This led to considerable discussion as to the methods and reasons why the corrosion was prevented. Reference was made to Faraday's laws, and to the results of the experiments of Helmholtz and Clausius. The best explanation is given in Professor Oliver J. Lodge's 'Modern Views of Electricity.' All the apparatus was designed in accordance with his theory and statements. Its operation has extended over a period of fourteen months, and with the exception of about ten tubes which have become pitted, the results have been satisfactory. When the condenser was planned, the condenser manufacturer was told to slope the tubes down one inch in the direction of flow; but when they performed the act, they forgot that the middle inclination, if parallel to the first and third passes, would then be uphill for the circulating water, and that when the condenser was shut down all the water would drain out of this middle section except that in the bottom tubes. These bottom tubes, it has been found, have become somewhat corroded, although not seriously.

The cause for this result having now been found, its prevention has been effected by perforating the diaphragm in the

condenser head to permit prompt drainage of these tubes when the condenser is taken out of active operation.   Considerable difficulty has been encountered in getting the system operated properly at the voltage suitable for the prevention of galvanic action in the hands of the regular operators, as they persisted for a long period in reading amperes instead of volts in adjusting the currents, thus not providing except by accident for the requirements.   The efficiency of the apparatus amply justifies the expense of its installation, while its operation is not expensive and the plant here described will now be followed by other protecting plants of the same character.

This paper forms a most excellent illustration of the application of theoretical physics to the solution of a concrete problem in commercial engineering. The saving of $100,000 a year in water rates at the expenditure of $250, or even more, per year, in a scientific preventive should be a sufficient answer to the commercial man who asks 'Does science pay?'

The paper on "The Justification of the Use of the Expression 'Engineering Mathematics,'" by Arthur E. Haynes, professor of engineering mathematics, University of Minnesota, Minneapolis, Minn., describes the conditions as they exist in a large university of the central west wherein mathematics is taught to students pursuing all kinds and classes of courses. The paper will be published in full in the *Proceedings of the Society for the Promotion of Engineering Education.*

The last paper, and in some respects one of the most interesting and valuable papers presented before Section D, was by J. J. Clark, manager of the text-book department of the International Correspondence Schools, Scranton, Pa., on 'The Correspondence School: Its Relation to Technical Education, and Some of Its Results.'

The paper will be published in full in the *Proceedings of the Society for the Promotion of Engineering Education* and will doubtless be abstracted by the technical press.

When Professor Edgar Marburg read a paper[3] in 1899 on 'The Correspondence School in Technical Education' there were about 80,000 students enrolled in the International Correspondence Schools.   In the following year this number had increased to 181,000.   Owing to a number of circumstances, it was impossible at that time to furnish reliable figures in regard to the work being accomplished.   Hence the reports which were made were both unsatisfactory and unjust to the correspondence school.   Since December 31, 1899, the school has grown at a rate of more than 100,000 per annum, the total number enrolled on June 27, 1906, was 902,906. After relating something of the history of the growth of the schools and their methods of securing students, the author describes their system of education as being based on ideas that are almost the direct opposite to those practised by the regular schools and colleges.   The regular technical school or college aims to educate a man broadly; the aim of the correspondence schools of the country is to educate him along some one particular line, and to make each course fit the particular needs of the student who takes it.   Hence, with a few exceptions, almost every one of the courses is a special course.

The author then describes other methods of conducting correspondence schools by the use of the regular text-books and correspondence concerning the difficulties encountered by the student.   The author states that such schools have always failed or made very little progress, 'for the reason that the ordinary text-book is not

[3] *Proceedings of the Society for the Promotion of Engineering Education,* Vol. VII., p. 80.

adapted to the use of the person studying by himself.' Another method is that of the University of Chicago, where students may take part of their regular college course at home. He can not, however, get his degree without taking the balance in residence. This plan offers few advantages over the regular college course. The only requirement necessary to become a student of the International Corespondence School is the ability to read the English language and to write it sufficiently well to be understood, or to possess the services of some one capable and willing to translate from the text-books and write out the dictation in English of the foreign-speaking student who is unable to use the English language.

The text-books differ, even on the same subject for the courses for which they are to be used; not only on the method of treatment, but principally in the examples given and the illustrations cited.

The author gives a number of reasons why students do not complete their courses, and also mentions cases of students who admit deriving much benefit from the course but who have never submitted an examination paper for correction. Their instruction has been obtained solely from the bound volumes which were furnished them when they enrolled. About 60 per cent. of the students send in one or more pieces of work. About two thirds of the students pay in full for their courses. While the present enrollment is a little over 900,000, the actual number of students is probably 60 per cent of this, or 540,000. During the year ending May 31, 1906, the total number of pieces of work received from students was 716,952. About one sixth of the number of active students have completed about one third or more of their course as shown by the records. The number of students who have entirely completed their courses, passed their final ex-

aminations and been awarded a certificate or diploma was 12,143 on June 27, or about 2.6 per cent. of the total number of active students. Between February 7 and April 21 the number of diplomas issued averaged 240 per month. The average for next year is estimated as high as 300 per month, or 2,700 diplomas for the year from this one correspondence school. As this number is about the same as the number of engineering degrees conferred per annum by all the technical colleges of the country, the amount of work that this represents, and the amount of education which is being obtained can be somewhat appreciated.

The social sides of the meeting were very well cared for by the committees of Cornell University, and have been described in the report of the general secretary. A special excursion was tendered to the section by the committee on Saturday afternoon in the form of a steamboat ride on the steamer *Iroquois,* down the lake, and which included a visit to the Remington Salt Works near Ithaca. Here steam is generated and used in steam engines for the generation of electric power, and the exhaust steam is used in the vacuum pans of the salt works. A feature of the meeting which appealed to every one was the delightful entertainment accorded to the members in the houses of the fraternities. Altogether the meeting was most enjoyable and profitable, and both the section and the Society for the Promotion of Engineering Education desire to extend their special thanks to the trustees, the faculty and to the fraternities who opened their houses at Cornell University. Wm. T. Magruder,
Secretary.

Ohio State University.

SECTION G—BOTANY.

In accordance with arrangements previously made the section met on June 29 for the transaction of business and the dis-